Assessment of the interannual evolution of water resources with an ensemble of fully coupled terrestrial model simulations

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In 2018, a severe drought occurred in Central and Northern Europe and water security concerns rose in regions where previously water was considered an abundant resource. Followed by another extremely dry year 2019, the meteorological drought developed into a hydrological drought and estimates on the probable evolution of water stores at an interannual time scale over Europe seem required that have the potential to provide informed options for adaptation. Utilizing the Terrestrial Systems Modeling Platform (TSMP) regional Earth system model over the 12km resolution pan-European CORDEX model domain, a probabilistic assessment methodology is proposed based on fully coupled groundwater-to-atmosphere simulations, which provide subsurface water resources anomalies for a water year defined from September to August. For the assessment, the TSMP ensemble is initialized with the surface and subsurface states at the end of a previous water year that is part of a spun up climatology run (here: 1989 to 2019). In an ensuing step, an ensemble of forward simulations is performed, driven by past ERA-Interim reanalysis meteorological boundary conditions until the end of August of the following year. The memory effect of groundwater, which is well-captured in TSMP, in combination with the different, plausible atmospheric states and evolution of the atmospheric forcing from the reanalysis, allows for a probabilistic assessment of the development of water resources in the upcoming year. The novelty is the use of the past meteorological conditions in a fully coupled model to account for the uncertainty of unknown weather conditions at the interannual forecasting time scale. We show that the method provides good results in a hindcast approach of 2018/19 and present the results of the upcoming water year 2019/20.